CHAPTER 1

BASIC DISPLAY DEVICES AND SYSTEMS

INTRODUCTION

Data display devices are those digital equipments designed to project, show, exhibit; or display soft-copy information. The information displayed can be alpha-numeric, graphic, or a combination of both formats. Some display devices are limited incapability to just alphanumeric display.

Display devices provide an interface between the human operator and the digital computer system (the man-machine interface). They allow the operator to view computer data, make decisions and modify the data, enter new data, and enter commands to be processed. Data entry is accomplished in a variety of ways. Personal computers and data terminal sets usually have a keyboard for entry and may have a mouse, pointer, or touch-sensitive screen. The display systems used in the Navy use a ball tab that is moved around the screen with a trackball.

Information displayed on the display device is not permanent. That is where the term **soft-copy** comes from. The information is available for viewing by the operator only as long as it is on the screen of the display. Most display devices use some type of cathode-ray tube (CRT) as the display medium; although other types of displays, such as liquid crystal display (LCD), are common in laptop personal computers.

After completing this chapter you should be able to:

- **Describe the operation of a cathode-ray tube (CRT).**

- **Describe the operation of *electromagnetic* and *electrostatic* deflection systems used in CRTs.**

- **Describe the operation of *interlaced scan, noninterlaced scan,* and *radar-scan* methods used to display images on a CRT.**

- **Describe the function and characteristics of the Data Display Group AN/UYA-4(V) and the Computer Display Set AN/UYQ-21(V).**

CATHODE-RAY TUBES

Most display devices currently in use employ a cathode-ray tube (CRT) for the display screen. The following information is a review of the fictions and operation of CRTs.

ELEMENTS OF A CRT

The CRT is a large glass envelope that contains three basic elements: an *electron gun,* a *deflection system,* and a *phosphor screen.* These elements convert electronic signals into visual displays. In our discussion of CRTs, we will first cover monochrome CRTs then we cover color CRTs.

All the air in the glass tube must be evacuated to form a vacuum. This is necessary for three reasons:

- Air molecules disrupt the electron beam as it travels from the anode to the cathode,

- Gases tend to ionize when subjected to high voltages and are conductive, which would short out the CRT, and

- Oxygen in the CRT would cause the filament to burn up.

Figure 1-1 shows the three basic components: the **phosphor screen,** the **electron gun,** and a **deflection system.**
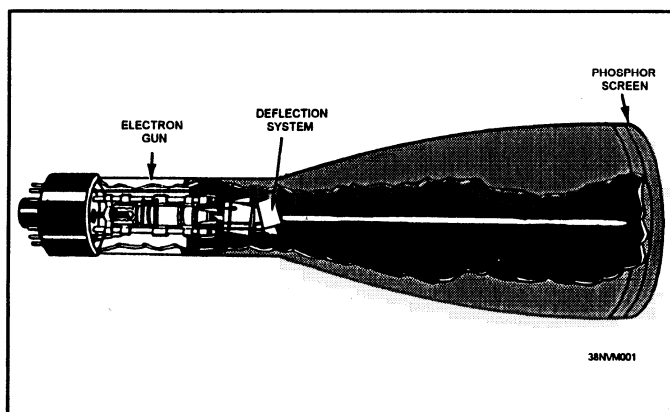

Figure 1-1.–A cathode-ray tube (CRT).

The Phosphor Screen

The inside of the large end, or face, of a CRT is coated with phosphor. Phosphor is a material that displays luminescence when excited by electrons or other sources of radiation. In other words, electrons (beta radiation) striking the phosphor will cause it to glow for a short period of time. The length of time or duration that the display remains on the screen after the phosphor has been hit with electrons is known as **persistence.** When the electrons are formed into a beam and directed at the phosphor, the beam produces a dot. The intensity, or **brightness,** of the dot is directly proportional to the intensity of the electron beam.

The Electron Gun

The electron gun is located in the narrow neck of the CRT. The gun acts as the source of the electron beam. Figure 1-2 illustrates the components of the electron gun.

A small ac voltage is applied to the filament to heat the cathode. Heating the cathode causes vast
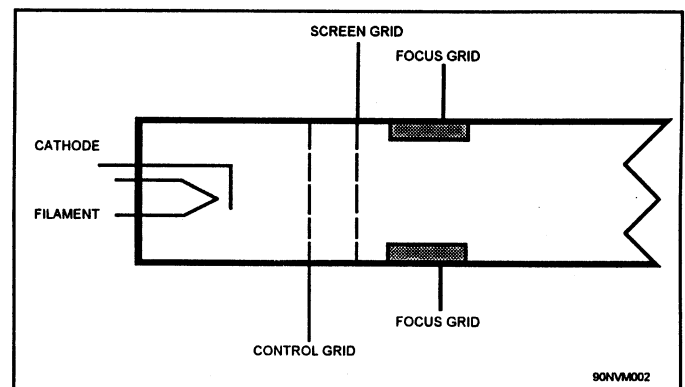

Figure 1-2.–A CRT electron gun.

numbers of electrons to be freed from the cathode. When the voltage of the control grid is more positive than the cathode, the beam is turned on, or **unblanked,** and the electrons are drawn to the anode (phosphor screen). When the control grid is negative with respect to the cathode, the beam is turned off, or **blanked.** In a monochrome CRT, the beam is either on or off and has a uniform brightness. In a black and white CRT that displays varying shades of gray, the

voltage of the control grid varies to control the strength of the beam. The stronger the beam, the brighter the display is on the phosphor screen.

The screen grid voltage remains constant and acts as an accelerator for the beam. A negative charge on the focus grid shapes the electrons into a beam. Varying the charge of the focus grid causes the diameter of the beam to vary to determine optimum focus.

Deflection Systems

The deflection system in a CRT moves the beams to create the display. Two common types of deflection systems are used in CRTs. These are **electromagnetic deflection** and **electrostatic deflection.**

ELECTROMAGNETIC DEFLECTION.– Electromagnetic deflection uses a magnetic field generated by four coils to move the beam across the CRT. Electromagnetic deflection is commonly found on CRTs that use a raster-scan type display.

Current flows through the electron beam as it moves from the electron gun (cathode) to the phosphor face (anode) of the CRT. This current develops a circular magnetic field. By introducing an external magnetic field, the beam can be deflected. Controlling the polarity and strength of this external field controls the amount and direction of the beam deflection.

The magnetic field is introduced into the CRT by the yoke assembly. The yoke consists of four coils of wire mounted at 90-degree increments. The yoke is mounted around the neck of the CRT. Current flowing through the coil produces a magnetic field at a right angle to the coil. The magnetic field will cause the electron beam to deflect.

ELECTROSTATIC DEFLECTION CRT'S.– Electrostatic-type deflection CRTs are generally used in radar and oscilloscopes. In the electrostatic deflection CRT, four deflection plates are located inside the CRT. The top and bottom plates control vertical deflection of the beam and the right and left plates control the horizontal deflection of the beam. An electrical charge is applied to these plates to direct the beam to the proper area of the CRT. To move the beam to the right, a positive charge is applied to the right plate to pull the beam while a negative charge is applied to the left plate to push the electron beam to the proper position. The amount of the charge applied to the plates controls the amount of deflection.

CRT SCANNING METHODS

The creation of a display is known as a scan. Two types of scanning systems are currently in use in CRTs: **raster scanning** and **vector scanning.** Raster scan CRTs are commonly used with electromagnetic deflection CRTs. Vector scan CRTs are commonly used with electrostatic deflection systems, although either deflection system can be used with either scanning system.

Raster Scanning

A raster scan CRT develops the display or picture by painting a series of horizontal lines across the face of the CRT. The electron beam is pulled from left to right. The beam is then turned off and the horizontal deflection voltage returns the beam to the left side, and the vertical deflection voltage pulls the beam down one line space.

The left to right motion is the horizontal frequency and is much greater than the top to bottom motion or vertical frequency. The time it takes for the beam to return to the left or top of the screen is known as *retrace time.* During retrace the beam is blanked.

By dividing the horizontal frequency by the vertical frequency, we can determine the maximum number of lines in the raster. Standard television uses 15,750 Hz for the horizontal frequency and 60 Hz for the vertical frequency. Using this formula, we find that the maximum number of lines is 262.5; but some lines are not available because of the time required for vertical retrace.

The lines are spaced close enough to each other so the eye cannot detect any variation of intensity. *Resolution* is the number of lines per inch at the
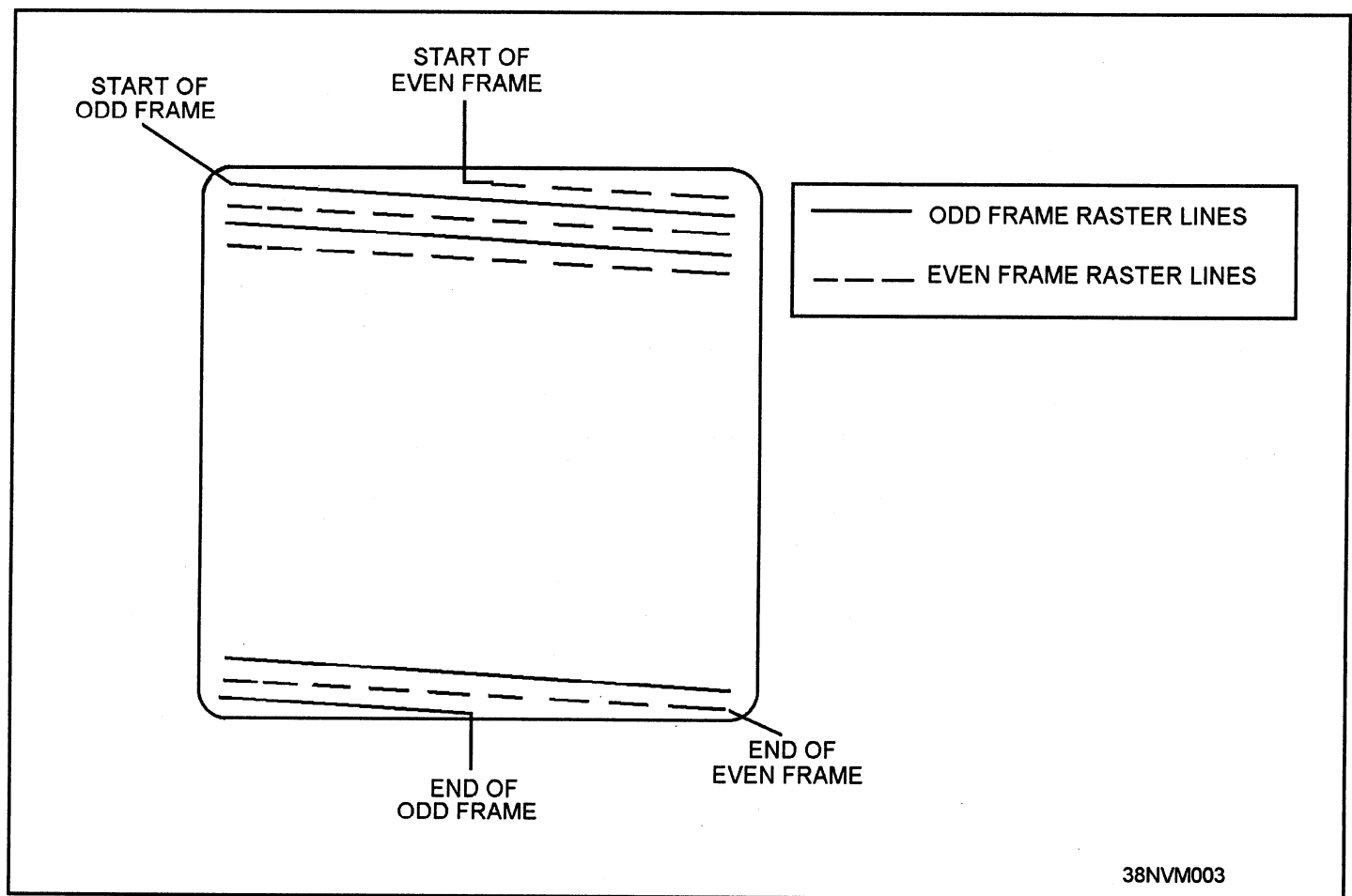
START OF
EVEN FRAME

START OF
ODD FRAME

ODD FRAME RASTER LINES

— — — EVEN FRAME RASTER LINES

END OF
EVEN FRAME

END OF
ODD FRAME

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Figure 1-3.-Interlaced scan of a CRT.

merge point. Two methods are used to increase the resolution of CRTs. These are **interlaced scan** and **noninterlaced scan.**

INTERLACED SCAN.– Interlaced scanning makes it possible to double the number of horizontal lines in a picture. Figure 1-3 illustrates the principle of interlaced scanning in which two scans are required to display the full picture. The odd raster starts in the top left corner of the CRT, while the even raster starts in the top center of the CRT. The two complete scans paint the entire picture. By interlacing the odd and even lines of a picture, resolution can be increased without a noticeable flicker on the screen. Interlaced scanning is used with standard television and some computer monitors. It increases the maximum number of lines per frame to 525. Because of the vertical retrace time, the number of visible lines is 512.

Interlaced scan CRTs are fine for television transmissions and alphanumeric displays, but can cause a visible flicker when displaying fine digital graphics because of the abrupt changes in the levels of intensity required. To solve this problem, most computer monitors use noninterlaced scan.

NONINTERLACED SCAN.– Noninterlaced scanning paints the entire frame of data from top to bottom. Figure 1-4 illustrates the noninterlaced scanning method of painting a single frame. To paint an entire frame without a noticeable flicker, the horizontal frequency is increased, which increases the number of lines per frame. The vertical frequency is also decreased from 60 Hz to 50 Hz in most monitors, which further increases the number of lines.
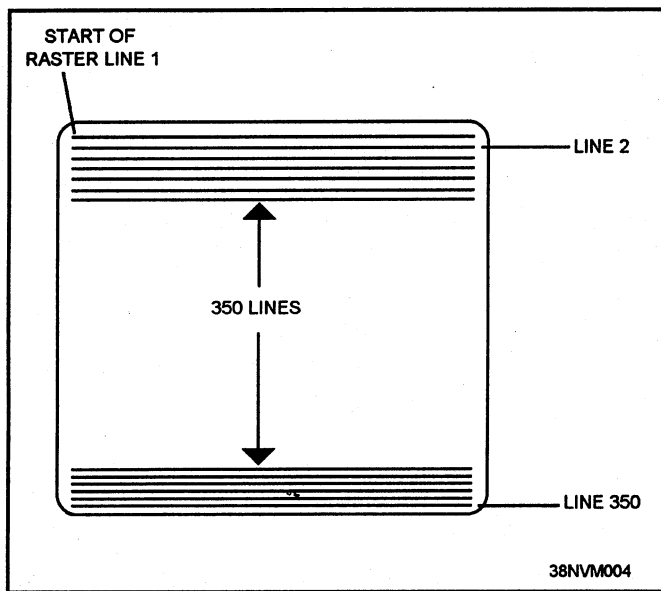
Figure 1-4.—Noninter1aced scan of a CRT.

Vector Scan

Vector scan CRTs are used extensively in the Data Display Group ANK/UYA-4(V) plan position indicators (PPIs). The circular display screens provide control and display of conventional radar sweep and video data and computer-generated symbology. The CRTs used in the PPIs use electrostatic deflection The methods used to develop the deflection and unblinking signals for radar sweep and video are similar because the same CRT beam is used to develop both presentations. However, the methods used to develop the radar sweep and video are different from the two methods used to develop symbology.

In the following paragraphs, you will learn how the X/Y coordinate system is used to position the CRT beam.

The X/Y coordinate system uses a grid as a frame of reference. Figure 1-5 illustrates the concept of the X/Y coordinate system. The horizontal line is the X axis, and the vertical line is the Y axis. The intersection of the two lines is the origin of all deflection signals. The origin is normally located at the center of the CRT, but may be offset from the center by operator action.
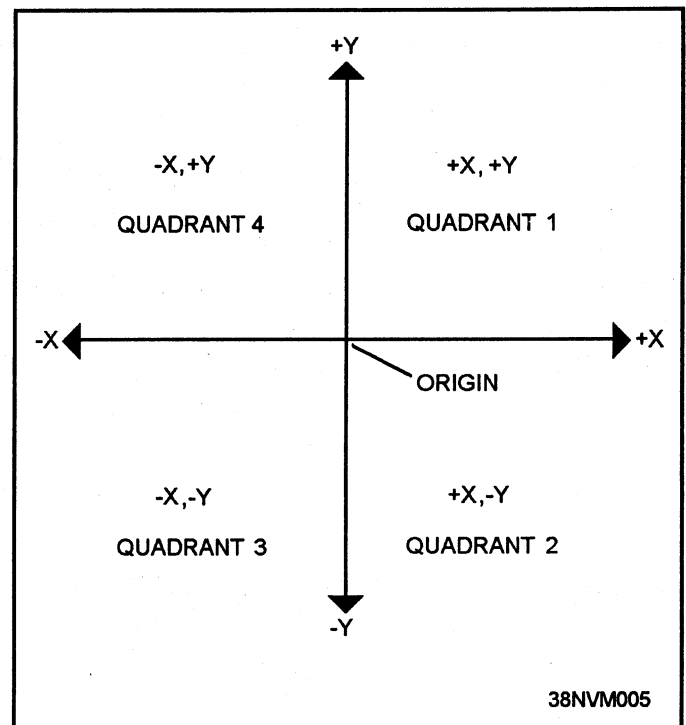

Figure 1-5.—The X/Y coordinate system.

The origin is the starting point for measuring along both axes. To the right of the origin, values on the X axis are positive; to the left, values are negative. The values above the origin on the Y axis are positive; below the origin, they are negative.

A point anywhere on the screen of the CRT may be defined by two values: an X coordinate and a Y coordinate. The X coordinate is used to develop the horizontal deflection of the CRT beam. A positive X value will move the beam to the right of the origin; a negative X value will move the beam to the left of the origin.

Vertical deflection is derived from the Y coordinate value. A positive Y value will deflect the beam upward from the origin, and a negative value will move the beam down. The appropriate X and Y values can be used to position the beam to any point on the CRT. The combination of positive and negative X and Y signals divides the CRT into the four quadrants illustrated in figure 1-5.

A third signal is required to control the blanking of the electron beam. The **Z (unblank)** signal is used

in the generation of symbology, for sweep retrace, and so forth.

We take you through a detailed look at how the vector scan CRT uses these signals to paint the display on the CRT later in this chapter.

COLOR CRT'S

Thus far our discussion has been about monochrome CRTs. Color CRTs offer a variety of colors and are used extensively with personal computers, simulators, and other training devices. Most color CRTs use a raster-scan type deflection.

The major differences between color and monochrome CRTs are in the phosphor coating of the CRT, the electron gun(s), and the high voltage requirements.

The phosphor coating of a color CRT is made up of small dots that contain a dye so they radiate one of the three primary colors of light (red, green, or blue). These dots are arranged in groups called **triads.** Figure 1-6 illustrates a typical grouping of triads.

The size of the phosphor dots is often used as a measure of the CRT's resolution. Newer monitors have CRTs with dots of .20 mm and smaller. The dots are the smallest addressable element of a picture. These picture elements are called *pixels* or *pels,* depending on the manufacturer. Both terms have the same meaning.

Three electron beams are required to properly strike the different colored phosphor dots. Some color CRTs use three electron guns, known as a delta gun CRT. The beams pass through a shadow mask that is designed so that only the red gun strikes the red dots, the blue gun strikes the blue dots, and the green gun strikes the green dots.

Newer color CRTs have combined all three electron beams into a single gun, as shown in figure 1-6. The single-gun CRT does not need convergence alignments and greatly reduces the amount of circuitry required in a color monitor. This design is common in almost all of the newer color monitors.
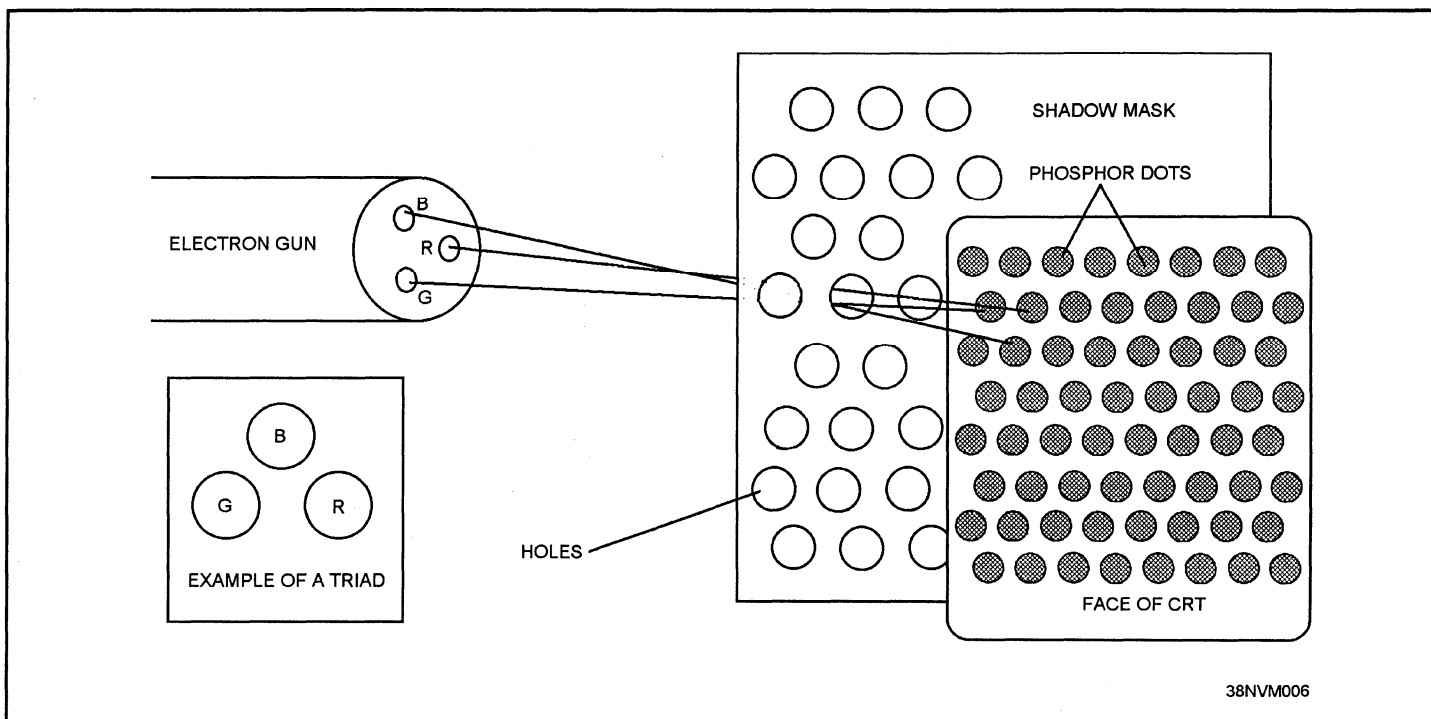

Figure 1-6.—A typical color CRT.

DISPLAYING RADAR SWEEP, VIDEO, AND SYMBOLS

In the following sections, we cover the steps involved in displaying radar sweep, video, and symbols on the PPI used in the Data Display Group AN/UYA-4(V).

RADAR SWEEP AND VIDEO

The PPI scan or sweep originates in the center of the circular screen. The sweep progresses (traces) outward until the edge of the screen or the end of sweep is reached. One sweep occurs for each radar pulse transmitted. The angle of the sweep varies as the position of the rotating radar antenna varies, resulting in a clockwise or counterclockwise rotation of the sweep on the screen. As the antenna is rotated, the sweep rotates around the CRT in synchronism with the antenna position.

The PPI provides real-time range and bearing display of radar, sonar, or IFF/SIF returns. The sweep trace is intensified (brightened) by video signals that indicate the range of the return. The angle of the sweep on the screen indicates the bearing of the return.

The PPI console sweep and video display is generated from data received from the radar, sonar, or IFF. Ancillary equipment converts the data into a format that can be used by the PPI console. The PPI console receives the following information from the conversion equipment:

- Digital sweep (digital $\Delta X/\Delta Y$ pulse trains)

- Sign of X and sign of Y

- Sweep timing (end-of-sweep and range-mark signals)

- Video

Digital Sweep

The digital sweep pulse trains ($\Delta X/\Delta Y$) are used to control the deflection of the CRT electron beam.

They indicate the changing sweep coordinates for the display of the rotating sweep.

Sign of X and Sign of Y

The sign of X and the sign of Y determine the quadrant in which the sweep and video will be displayed.

Sweep Timing

Sweep timing signals include range-mark signals and the end-of-sweep signal. The zero-mile range mark is used to start the sweep deflection outward from the center of the screen. Other range-mark signals are displayed as intensified rings on the CRT so that a relationship between the radar video and range may be established.

The end-of-sweep signal causes the CRT beam to be blanked and retraced to the center of the CRT. The end-of-sweep signal also resets various counters in preparation for the next sweep.

Video

Radiation reflections from the radar, sonar, or IFF/SIF are received as video signals. The video signals are displayed as an intensification of the sweep.

SYMBOL GENERATION

The generation of display symbology is integrated with the development of the sweep and video. Symbols are generated from data words outputted by the computer. The following steps are required to paint a symbol:

1. Blank the sweep

2. Move the CRT beam to the symbol coordinates

3. Paint the symbol

4. Blank the CRT beam

5. Move the beam back to sweep position

Figure 1-7.—The AN/UYA-4(V) symbol set.

Two different methods of painting symbols are currently in use in the AN/UYA-4(V) display group. They are the **analog waveform** and the **digital stroke methods.** The symbols being generated are the same in either case, only the methods used to generate the symbols differ. Figure 1-7 shows the symbol set used in the AN/UYA-4(V) display group.

The AN/UYQ-21(V) computer display set has an expanded symbol set and develops sweep and symbols using both the digital stroke method and raster-scan CRTs, depending on the type of console. Figure 1-8 shows the AN/UYQ-21(V) symbol set.

Analog Waveform Symbol Generation

To help you to fully understand the analog waveform generation process, we look at the equipments required and the procedure that takes place.

Analog symbols are formed by applying harmonious waveforms to the deflection plates of a CRT. For example, if two sine waves of equal amplitude and 90-degrees out of phase are applied to the X and Y axes of a CRT, a circle will be displayed on the CRT. By adding the Z, or unblinking signal, we can control what part of the circle is actually displayed and thus form the symbol. Ellipses are formed when the amplitudes of the two sine waves are unequal.

Using the same principle with two trapezoid waveforms that are 90-degrees out of phase, a square will be formed.

1-8

Figure 1-8.—The AN-UYQ-21(V) symbol set.

Symbols are defined by computer words. The computer, using data input by the operator, determines what symbol to display and where to display it on the X/Y grid. It then puts together a digital message and transmits it to a piece of ancillary display equipment called a pulse amplifier/symbol generator (PA/SG). Figure 1-9 illustrates how the pulse amplifier interfaces the computer with the symbol generator and the display consoles. It amplifies and distributes the computer output data to the symbol generator and the display consoles. The pulse amplifier also receives computer input data from the display consoles and sends it to the computer.

When a symbol message is sent to the display equipment, the console takes control of the CRT electron beam from the radar scan logic. It positions the blanked CRT beam to the coordinates of the symbol to be displayed and waits for the symbol waveforms from the symbol generator.

The symbol generator develops the symbol waveforms and timing pulses for the mechanization (display) of the symbol. The timing pulses synchronize the console's painting of the symbol. Each symbol is composed of the following three
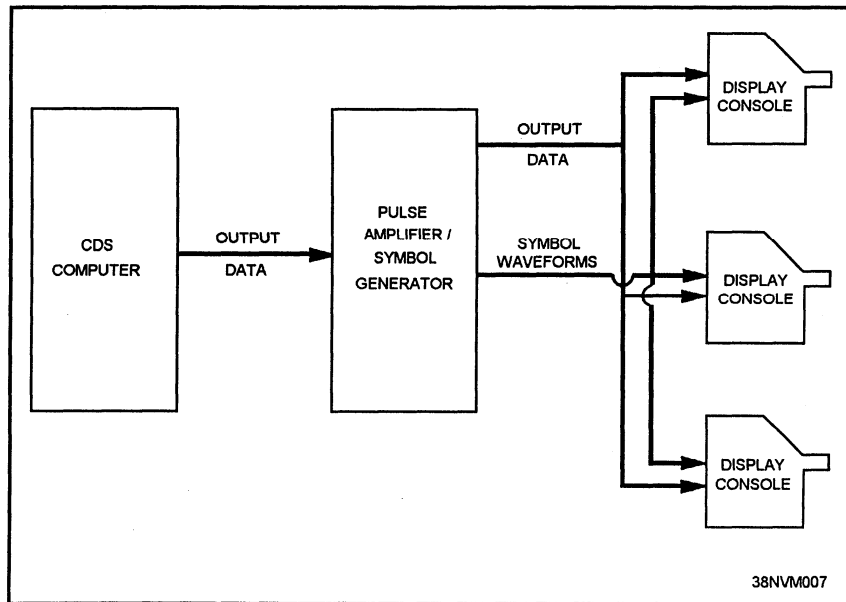
Figure 1-9.—The waveform symbol equipments (PA/SG) interface path,

signals: **X-axis waveforms, Y-axis waveforms,** and **Z (unblinking) signals.**

The symbol is painted in a timing period called **P-time.** The symbol generator, using a series of P-time interval signals, develops the proper waveforms to be sent to the CRT deflection amplifiers and video amplifiers. When the symbol generator starts its P-time counter, a signal is sent to the display console that starts an identical counter in the console. This ensures that both equipments are synchronized. Figure 1-10 shows the development of a symbol using the X, Y, and Z waveforms. The symbol is formed during the unblanked P-time intervals. The symbol shown in figure 1-10 is actually a combination of three symbols: air unknown, rocker, and full upper bar. The unblank times have been given reference letter designations to aid you in following the mechanization process.

During unblank time A, the rocker is formed. Figure 1-11 illustrates this process on an X/Y plot. When the unblank signal is high, the X sine wave is at its negative point and transitions to its positive point. At the same time, the Y waveform is at zero and transitions its negative cycle, and returns to zero.

During unblank B, the Y waveform provides the proper position for the upper bar, while the X waveform transitions from negative to positive. The unknown air symbol is formed during unblank time C.

Note that with the trapezoid waveform, X remains at a constant negative level, while Y goes from zero to the positive level. This draws the left vertical side of the symbol. When Y reaches its positive level, X starts a transition from negative to positive to draw the top of the symbol. The right side of the symbol is formed when the Y waveform goes in a negative direction to zero, while X remains at a constant positive level. The dot is formed at unblank time D by unblinking X and Y at the zero level. At the completion of the P-time, the console returns control of the CRT beam to the radar scan logic.

The symbol remains displayed on the screen as long as the persistence of the screen phosphor permits. For the symbols to remain flicker free, they must be periodically refreshed, or repainted, by repeating the process just described. Symbols are refreshed 15 to 20 times per second.
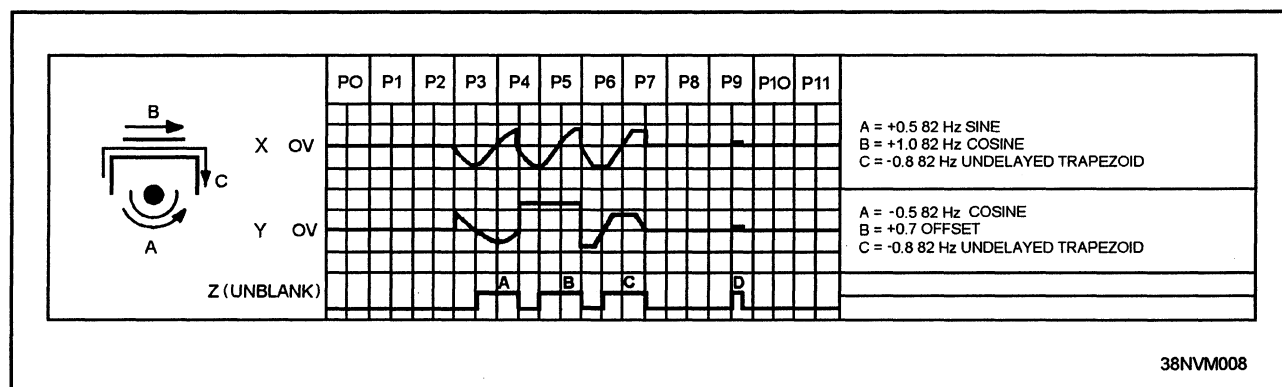
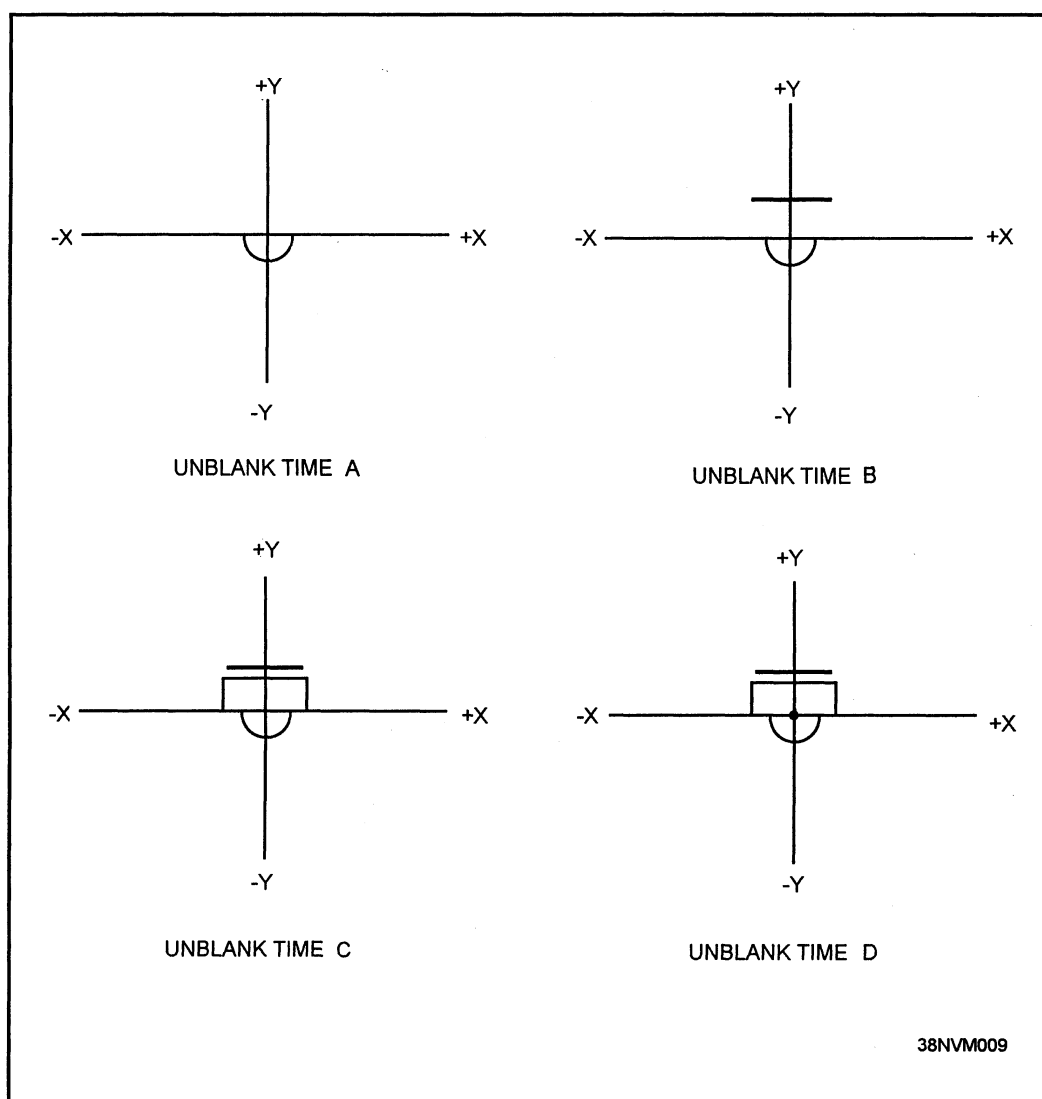Figure 1-10.—Development of an analog waveform symbol.

Figure 1-11.—The mechanization of an analog waveform symbol.

Digital Stroke Symbol Generation

The digital stroke method of symbol generation is used in some AN/UYA-4(V) display groups that use the console internally generated and refreshed symbols (CIGARS) modifications of the digital stroke symbol generator. The CIGARS modified console eliminates the need for a separate symbol generator because each console contains its own symbol generation circuitry.

The digital stroke symbol generator stores all symbols as digital codes in a group of read-only-memory (ROM) chips or programmable read-only-memory (PROM) chips. In this example, we assume that a PROM is the device that stores the symbol. The computer sends a message to the display group indicating what symbol needs to be painted. The message is translated and the data bits that were used to identify the symbol in the analog symbol generator are sent to the stroke control logic and are used to access stroke codes from a PROM.

There are eight distinct routine states or time periods in the symbol routine process as shown in table 1-1. During each routine time, a component of the symbol to be displayed is mechanized. At the start of the symbol generation process, the CRT beam is moved to the location where the symbol is to be painted.

Table 1-1.-Symbol Routine States

ROUTINE TIME	SYMBOL MECHANIZATION ROUTINE
0	Dot time
1	Symbol time
2	Upper bars modifier time
3	Raid size modifier time
4	Lower bars modifier time
5	Missile rocker modifier time
6	Threat modifier time
7	TSLO modifier time

The stroke symbol generator paints the dot first, then accesses the PROM to get the symbol strokes. The PROM has eight outputs for each address. Each output performs a particular function in the generation of the symbol component. The eight output lines used to mechanize the symbol are as follows:

- Sign X, X, 2X
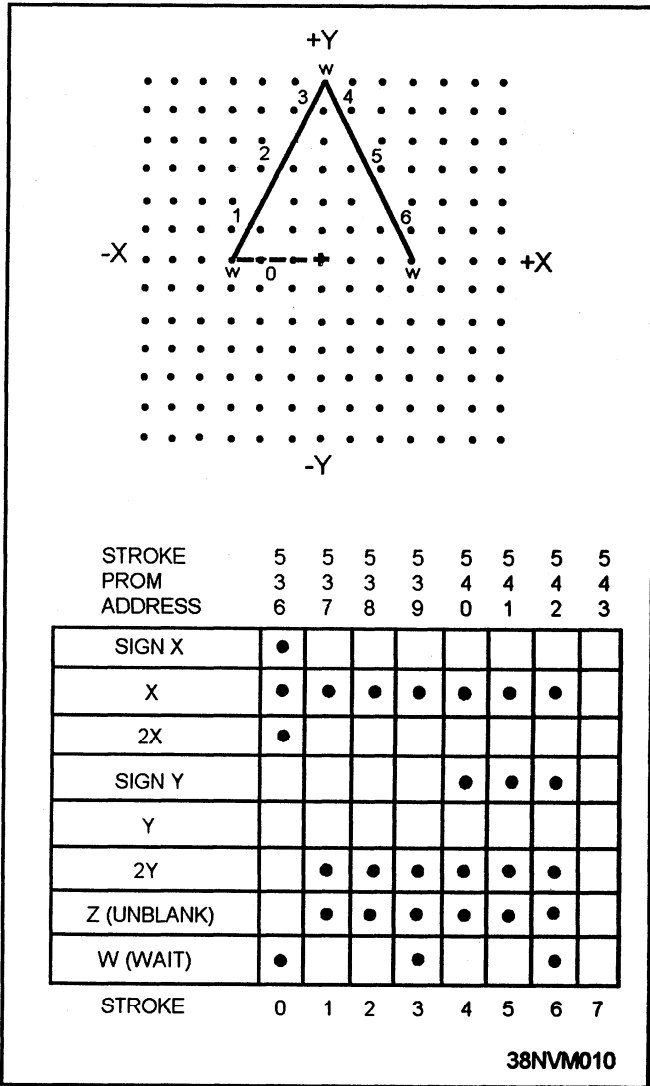
- Sign Y, Y, 2Y

- Z (unblank)

- W (wait)

STROKE PROM ADDRESS	536	537	538	539	540	541	542	543
SIGN X	●							
X	●	●	●	●	●	●	●	
2X	●							
SIGN Y					●	●	●	
Y								
2Y		●	●	●	●	●	●	
Z (UNBLANK)		●	●	●	●	●	●	
W (WAIT)	●			●			●	
STROKE	0	1	2	3	4	5	6	7

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Figure l-12.—The symbol grid and stroke PROM addresses.

Figure 1-12 shows the mechanization grid for the hostile air symbol. A dot in the grid indicates the function is active. The sign bits control the direction of the beam. If the sign bit is active, the beam is moved in a negative direction. The X, 2X, and Y, 2Y bits combine to determine the amount of deflection:

zero, one, two, or three grid points. The Z (unblank) signal unblanks the beam when active. The W (wait) output is used to ensure the completion of a stroke before the start of the next stroke. The W fiction is normally used to ensure the CRT beam is in the proper position before the beam is unblanked, blanked, or makes a major change in direction. This prevents distortion of the symbol that could result if the beam has not completely finished a stroke or has not been completely repositioned.

Referring to figure 1-12, the PROM is addressed and the output is translated. In this example, the first stroke (stroke zero) positions the CRT beam three grid spaces in the -X direction and the beam is blanked. Upon completion of this stroke, the next address is read and translated. Strokes one, two, and three each cause the beam to be deflected one grid space in the +X direction and two grid spaces in the +Y (up) direction while the beam is unblanked. At the end of stroke three, there is a pause (W) so the beam can finish the stroke before changing direction.

Strokes four, five, and six each cause the beam to move one grid space in the +X direction and two grid spaces in the -Y (down) direction. Again at the end of stroke six, there is a pause (W) to ensure that the beam deflection is complete.

When the PROM address for stroke seven is read, no outputs are found active. This condition signals the logic that the symbol is complete, and the symbol generator moves to the next fictional time period, as shown in table 1-1.

DISPLAY SYSTEMS

The combat direction systems (CDS) in use on most ships evolved from the original NTDS systems. These systems developed the standards for several digital computer protocols, and the term NTDS is still used to define several of these protocols. The display sub-system is the largest part of the CDS system.

Two major tactical display systems are currently used in the fleet. These are the Data Display Group

AN/UYA-4(V) and the Computer Display Set AN/UYQ-21(v). Within each system different versions are tailored for each class of ship, according to the mission of the ship.

DATA DISPLAY GROUP AN/UYA-4(V)

The Data Display Group AN/UYA-4(V) is the most widely used system currently in the fleet. It was developed to refine the limitations of the AN/SYA-4(V) and the AN/UYA-1(V) systems. The AN/UYA-4(V) display group uses third generation electronics (integrated circuit) for all logic functions.

The function of the Data Display Group AN/UYA-4(V) is to provide a real-time visual picture of the tactical situation. To perform this requirement, the systems must be able to accomplish several tasks including the following:

- Sensor data distribution and display

- Tactical data distribution and display

- System simulation and testing

Figure 1-13 illustrates a typical AN/UYA-4(V) display group. Sensor position data is received from the ship's sensor platforms (radar and sonar) and sent to a converter for conversion into a form that can be used by the display console. The converted position data is routed to the display console through a distribution switchboard. Sensor video data is routed to the display consoles through the same switchboard.

Tactical data is digital data received from or transmitted to the system computer. Tactical data from the computer is used by the display system to generate symbol displays and alert/switch indications on the display consoles. Tactical data sent to the computer is the result of some type of operator action at the display console.

System test is accomplished with the system computer and the video signals simulator (VSS). As illustrated in figure 1-13, the VSS can simulate a radar input to the switchboard to aid the technician in fault isolation or provide simulated data for operator training. The tactical data paths can be tested using the various software programs (POFA, PEFT, etc.) designed to run with the system on your ship.

COMPUTER DISPLAY SET AN/UYQ-21(V)

The Computer Display Set AN/UYQ-21(V) is the latest display system in the Navy. It is installed on the newer ships and is replacing older AN/UYA-4(V) systems as part of the new threat upgrade. The AN/UYQ-21(V) system is also configured according to the mission of the ship. A typical configuration could include tactical display consoles, display control consoles, and large screen projection displays. The system also offers expanded symbol sets and locally generated programmable symbols.

As with the AN/UYA-4(V) system, the AN/UYQ-21(V) system provides a real-time picture of the tactical situation.

SUMMARY-BASIC DISPLAY DEVICES AND SYSTEMS

In this chapter, you were introduced to the basic element of most display systems, the CRT. You were also introduced to the two display systems the Navy is currently using. The following information summarizes some of the important points you should have learned.

CATHODE-RAY TUBE (CRT)— The cathode-ray tube (CRT) is the focal point in most display devices. It provides a visual display of data for the operator to interface with the computer. The CRT has three functional areas: a phosphor coated screen, an electron gun, and a deflection system.

PHOSPHOR SCREEN— The screen or face of the CRT is coated with phosphor, which glows when bombarded with electrons.

ELECTRON GUN– The electron gun in a CRT is the source of the electron beam. The electron gun also contains the control circuitry for the unblinking and focusing of the beam.

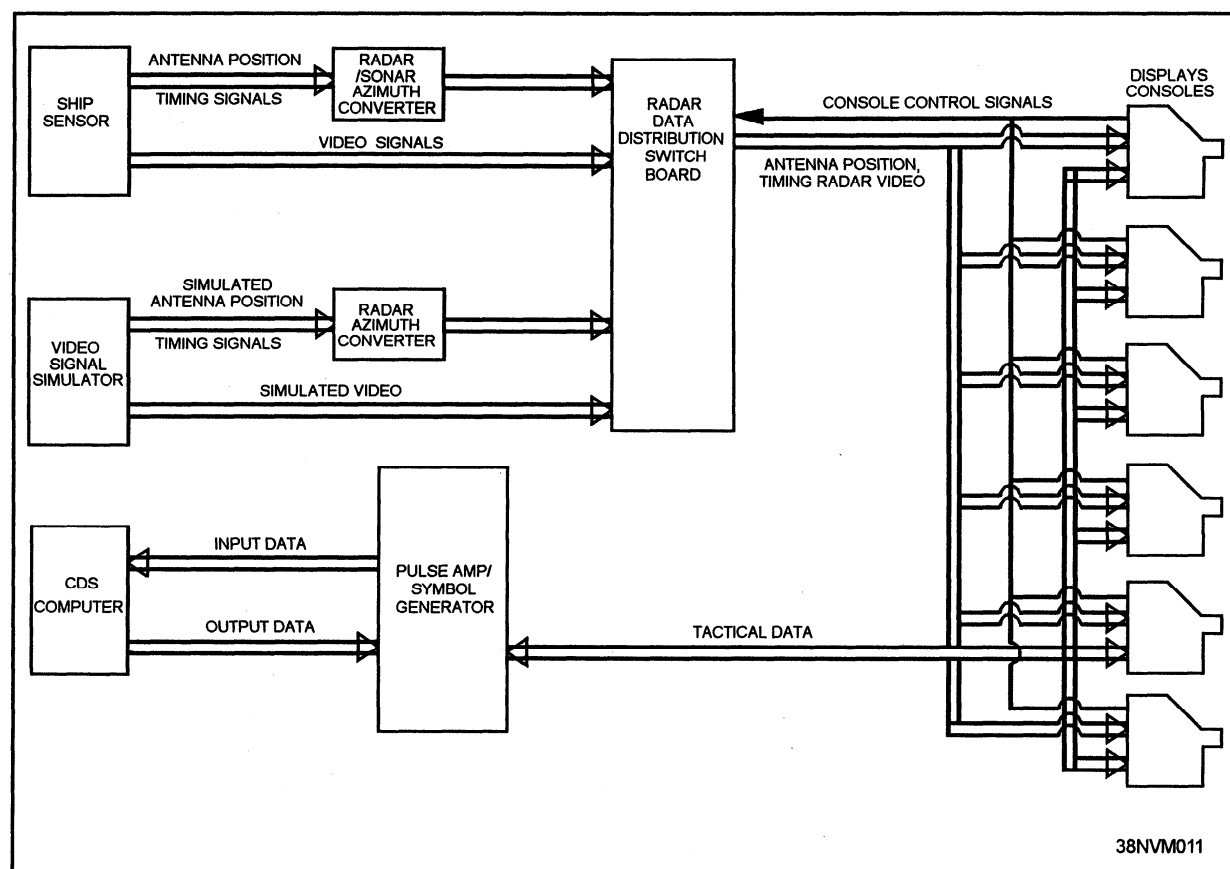**CRT DEFLECTION SYSTEMS–** Electromagnetic deflection and electrostatic deflection are the

Figure l-13.—The AN/UYA-4(V) data display system (typical).

two major types of deflection systems used to move the electron beam around the face of the CRT. Electromagnetic deflection systems use a series of coils mounted on a yoke to generate a magnetic field. The strength and polarity of the magnetic field cause the beam to deflect. Electrostatic deflection systems use four deflection plates mounted inside the CRT to move the beam. A voltage is applied to each plate. The polarity and strength of the voltage determine the amount and direction the beam is moved.

CRT SCANNING– CRT scanning moves the electron beam around the face of the CRT to create the display. The two methods of CRT scanning are raster scanning and vector scanning.

RASTER SCANNING— Raster scanning develops the display by painting a series of lines across the CRT. There are two types of raster scan: interlaced scan and noninterlaced scan. Interlaced scan uses a method of painting all the even lines of a frame from top to bottom, then returning to the top of the CRT and painting the odd frames. It is used in television and low resolution digital monitors. Noninterlaced scan paints each frame as a series of consecutive horizontal lines and is used with most digital monitors. Noninterlaced scan is used to increase the resolution of the display.

VECTOR SCANNING– Vector scan CRTs have the ability to move the electron beam to any desired point on the CRT at any time. They are used in oscilloscopes and many radar display consoles. The electron beam is moved to the desired location by using an X/Y coordinate system that defines the exact location of the beam.

COLOR CATHODE-RAY TUBES– The color CRT works in a very similar manner to the monochrome CRT. The major difference is that the color CRT has three electron beams that are synchronized to strike dyed phosphor dots on the face of the CRT. These dots are red, blue, and green, the primary colors of light.

DISPLAYING RADAR SWEEP, VIDEO, AND SYMBOLS– The AN/UYA-4(V) data display group uses vector scan CRTs in the plan position indicator (PPI). The PPI is usually under the control of the radar sweep logic and switches to symbol display logic when a message is received from the computer.

RADAR SWEEP AND VIDEO– Radar sweep originates in the center of the CRT and travels outward until the edge of the CRT or the end-of-sweep signal is reached. The radar azimuth is developed by ΔX and ΔY pulse trains developed by a piece of ancillary equipment. Video returns are displayed as intensified sweep.

SYMBOL GENERATION– Symbols are generated from data messages outputted by the computer. Two methods of painting symbols are used in the AN/UYA-4(V) system: the analog waveform method and the digital stroke method. The analog waveform method uses a separate piece of equipment called a symbol generator. The symbol generator decodes the computer messages and generates X, Y, and Z waveforms to paint the proper symbo1. The X and Y waveforms are applied to the CRT deflection plates, while the Z waveform controls the unblinking of the electron beam. The digital stroke method stores the symbol in ROMs or PROMS as digital codes. The digital stroke symbols are generated by each console when the console is equipped with the console internally generated and refreshed symbols (CIGARS) modification or by a type of symbol generator.

DISPLAY SYSTEMS– The Navy currently uses two major display systems in the fleet: the Data Display Group AN/UYA-4(V) and the Computer Display Set AN/UYQ-21(V). Both systems are designed to provide a real-time display of the tactical picture using ship's sensor data and tactical data from the CDS computer.